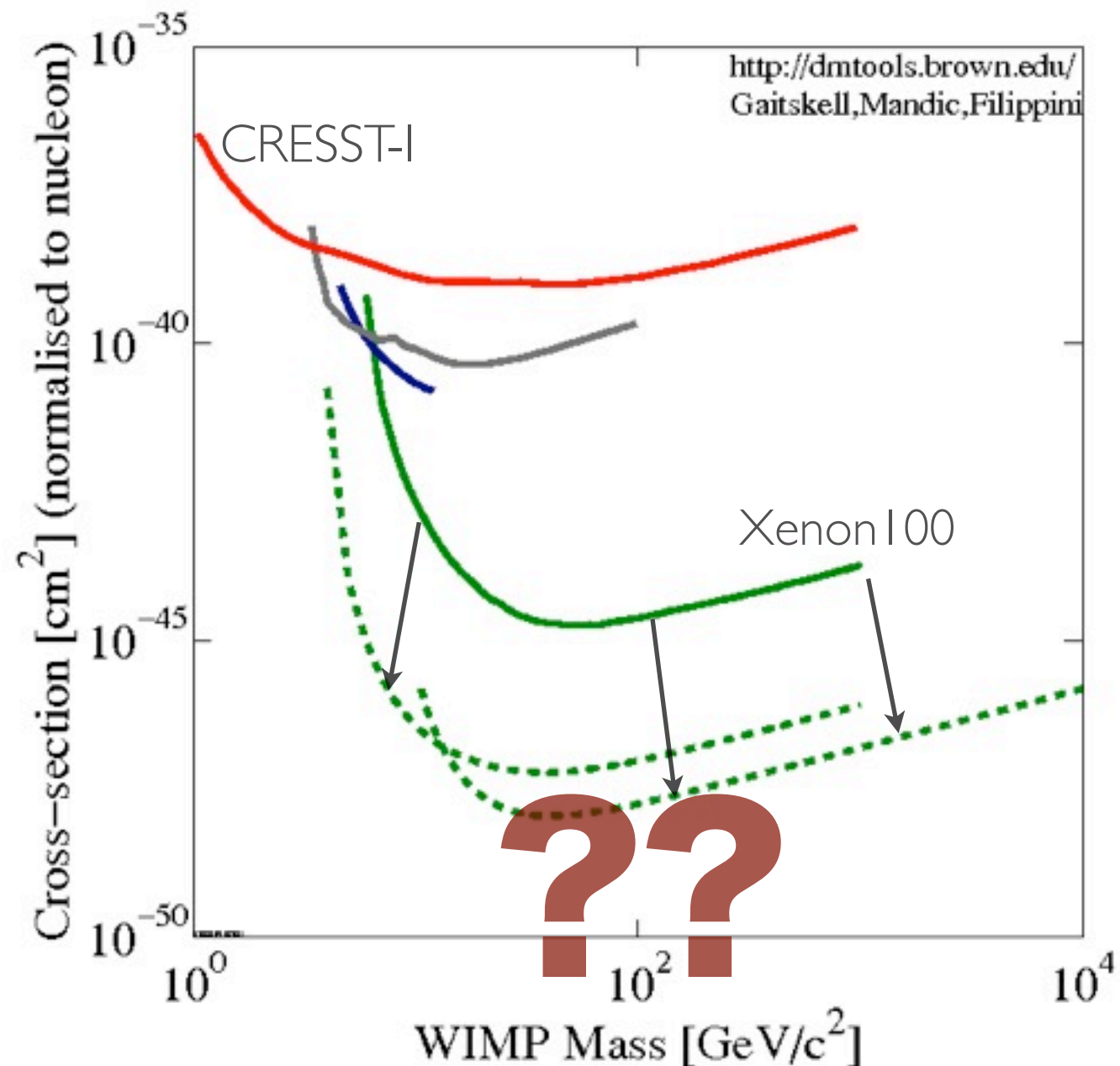


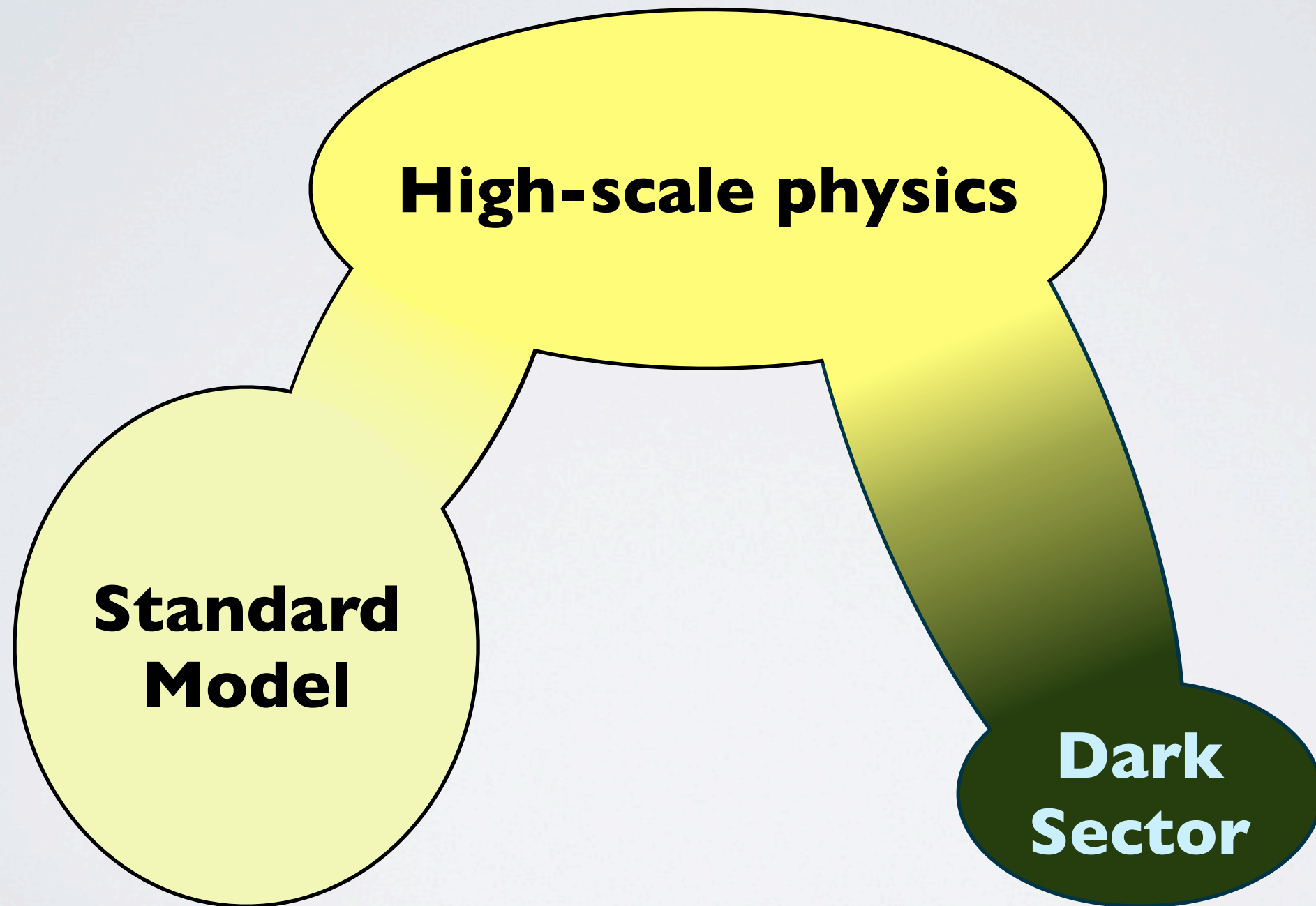
DIRECT DETECTION BEYOND THE WIMP PARADIGM

IS THERE NO NEW WEAK-SCALE PHYSICS?



VARIETIES OF SUB-GEV DM

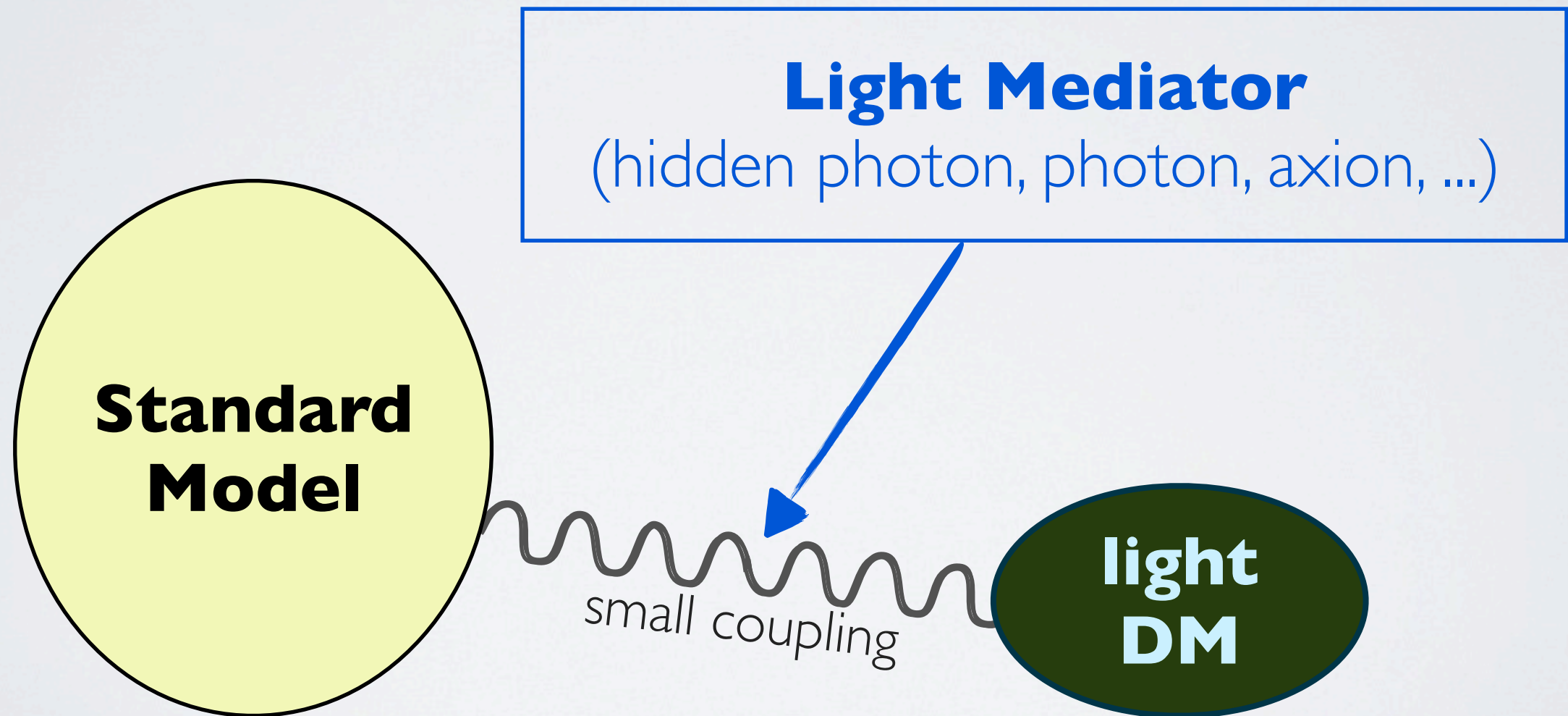
(an illustrative example)



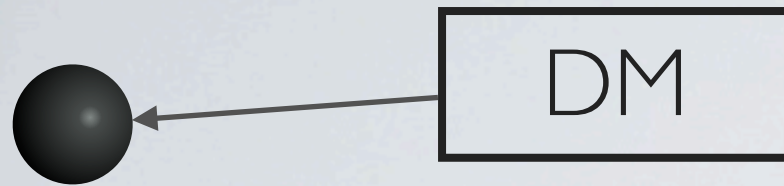
VARIETIES OF SUB-GEV DM

(an illustrative example)

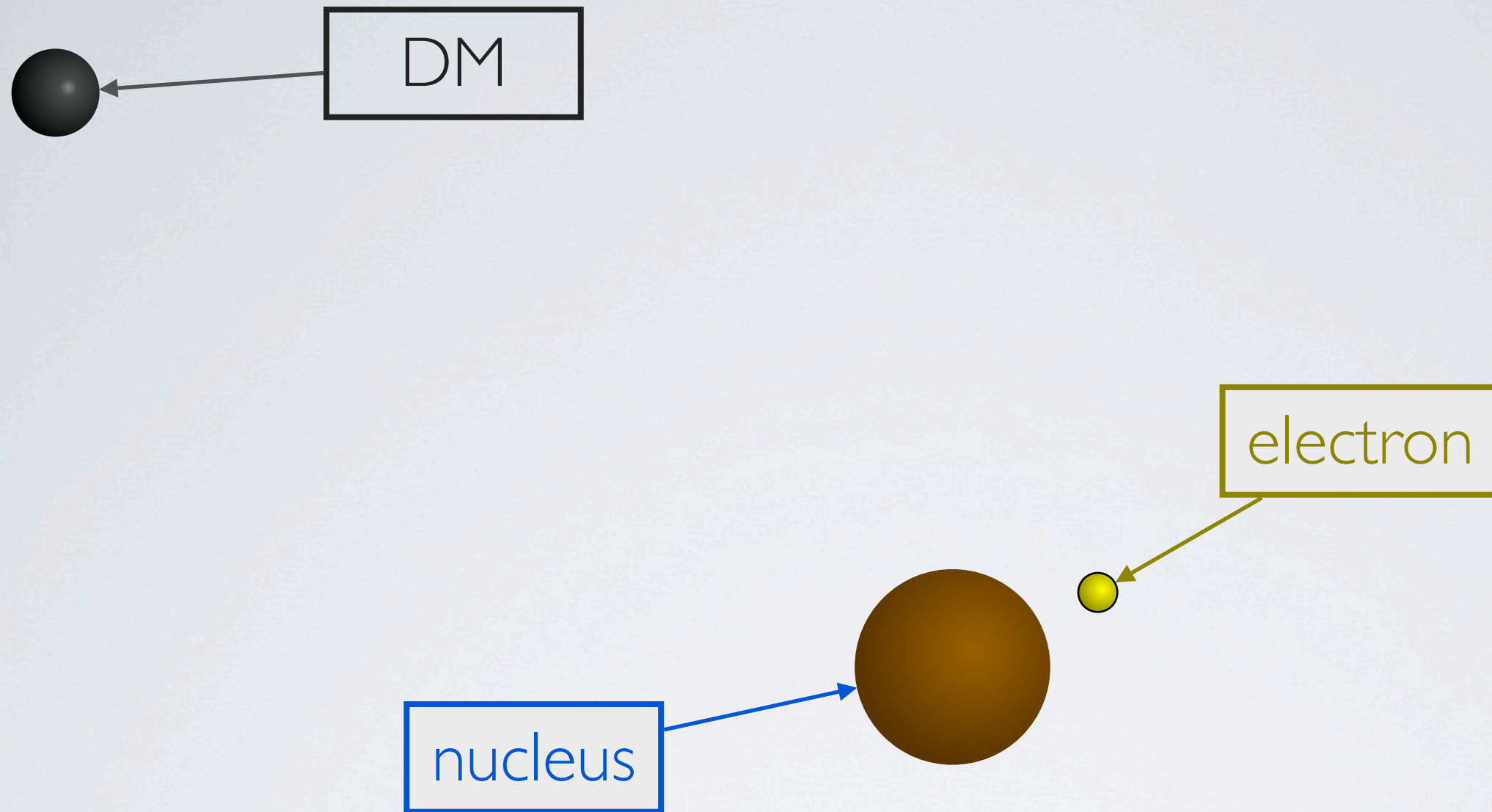
Low-energy effective theory



See e.g. 1108.5383, 1111.0293, 1112.0493,
1203.2531, 1203.4854, 1302.3898



Nuclear scattering transfers very little energy!



Energy available \approx eV (m_{DM}/MeV)
Electron scattering can transfer most of energy

Strategy:

Search for DM scattering with *electrons*

Signal is a single (or a few) ionized
electrons

Sensitivity down to MeV scale

“Direct Detection of Sub-GeV Dark Matter”

Essig, Mardon & Volansky

arXiv:1108.5383

see also Graham, et al 1203.2531

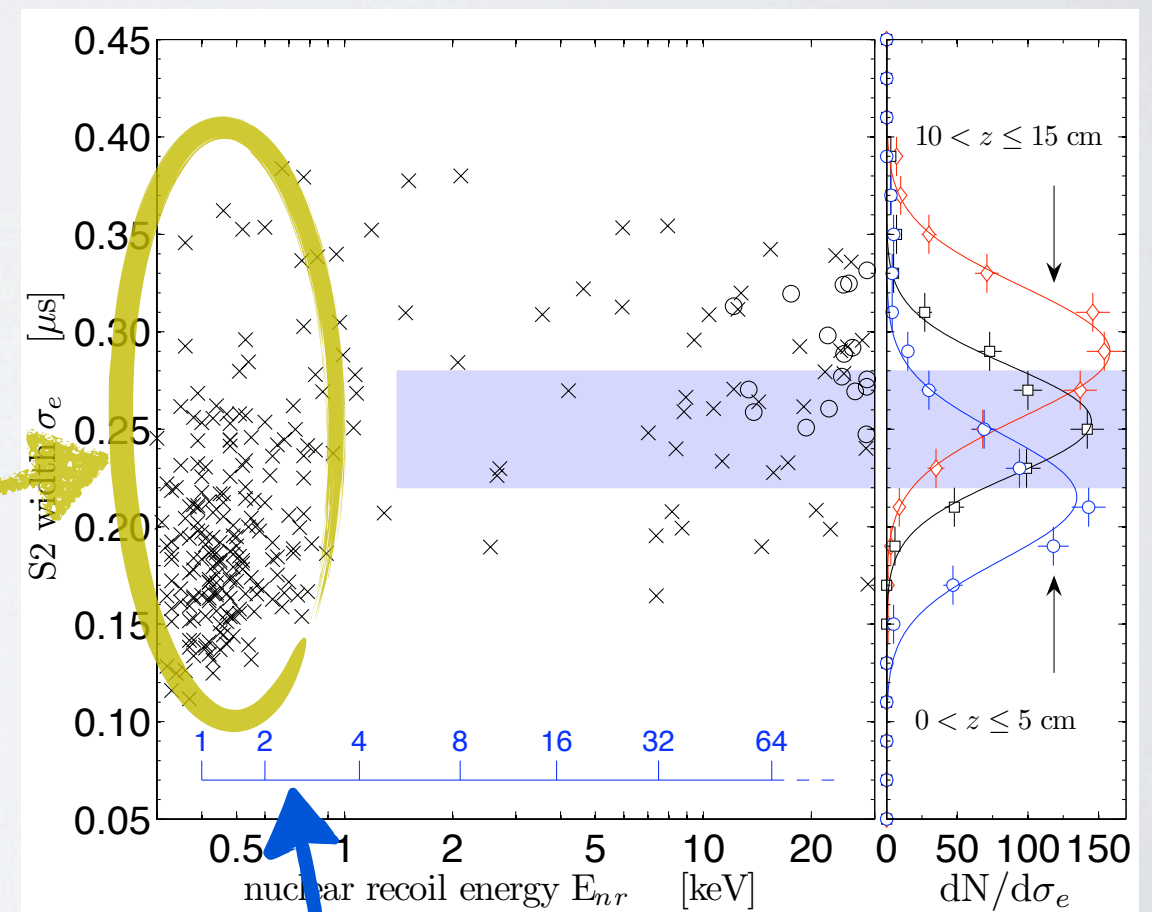
PROOF OF PRINCIPLE: XENON10

XENON10:

- Incredible sensitivity: could measure single electrons
- Hardware trigger only recorded single electrons during a 15 kg-day exp. in 2006
- Published in 2011

“A search for light dark matter in XENON10 data”
1104.3088

single/few-
electron events

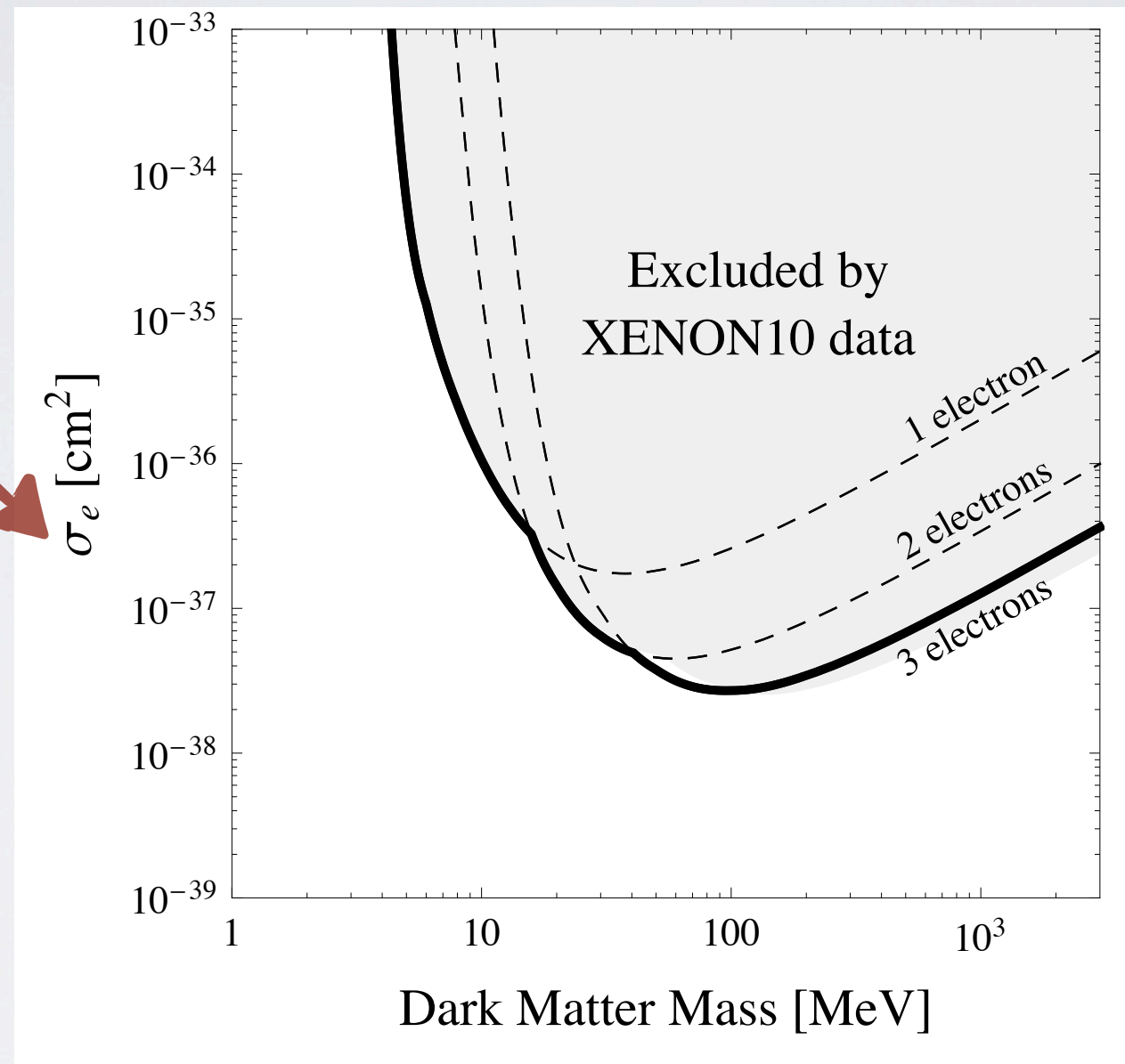


number of ionized electrons

PROOF OF PRINCIPLE: XENON10

First Direct Detection Limits on sub-GeV DM

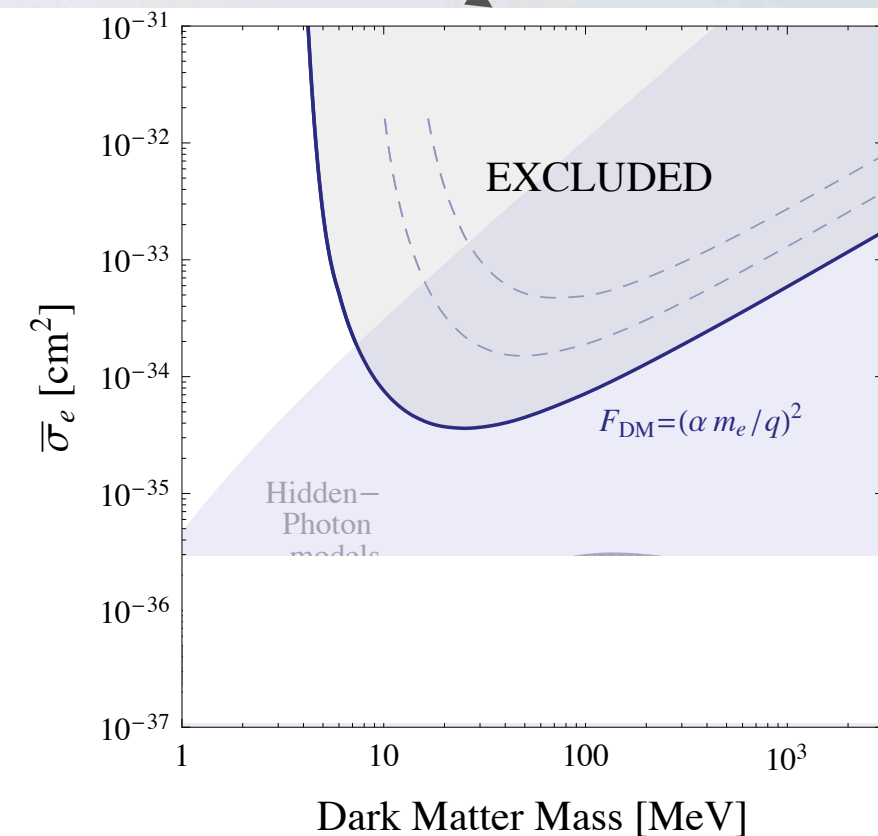
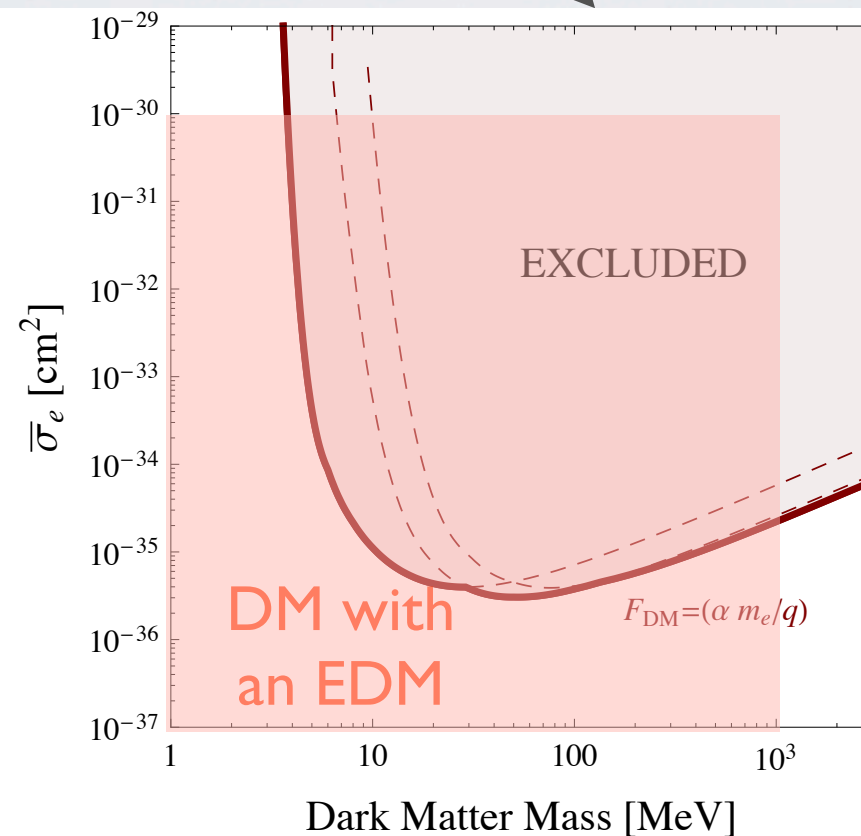
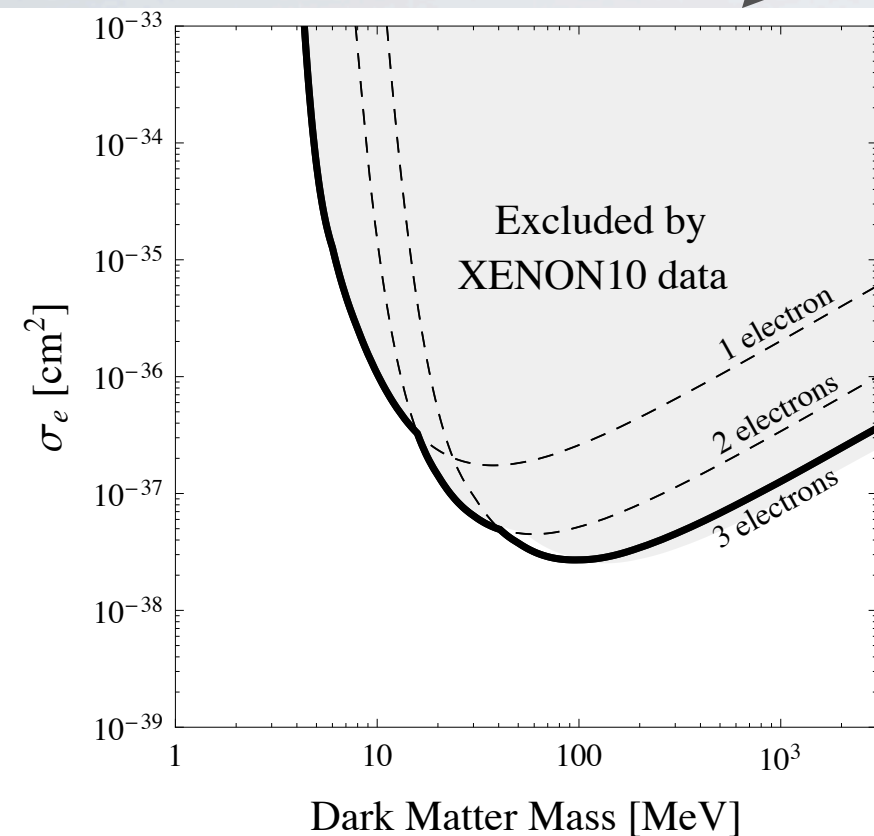
cross-section to
scatter with free
electron



Essig, Manalaysay, Mardon, Sorensen & Volansky
arXiv:1206.2644

HOW DOES THIS COMPARE TO MODELS?

different momentum-dependence of
DM coupling



Real models already being probed...
without even trying

THE FUTURE

Backgrounds poorly understood

- **study needed!**

Dedicated study soon in XENON100 and LUX?

Single-electron sensitivity in Si/Ge detectors?

- lower ionization thresholds
- technology being developed by CDMS

Discrimination of signal/background events?

- **discovery through annual modulation (~10%)?**
- **some other clever idea?**

CONCLUSION

Direct detection CAN probe DM masses all the way down to the MeV scale!

Technology & understanding of backgrounds is developing fast.

Naturally piggyback on conventional WIMP searches

We can already place direct detection constraints in the MeV-GeV range.

**Watch out for XENON100 & LUX analyses soon
+ CDMS in the next few years**

BACK UP SLIDES

PROOF OF PRINCIPLE: XENON10

Extracting limits on 1-, 2-, and 3-electron rates:

(skipping many important details...)

$$R1 < 39$$

limits: $R2 < 4.7$ counts per kg-day

$$R3 < 1.1$$

at 90% CL

DM--electron
interaction

(skipping details of
calculation...)

limits on
DM--electron
scattering